Review Article

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Adolescent Sports-Related Concussion: US Healthcare Access, Finance, and Delivery

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Abstract

The current United States health care systems has challenges and inconsistencies resulting from deficiencies in prevention and the optimal management of the sports-related concussion that goes beyond the acute injury. The current system leads to gaps in optimal care for children beginning with coaches who fail to identify a sport-related concussion, remove a player from the practice or game or properly assess the player for a concussion before returning them to play according to each states' laws; to more systemic problems that result from lack of communication with parents and school officials. The result is a delay in diagnosis and treatment, and in the provision of follow-up health services, concussion-related educational and insurance-related services and applicable insurance waivers. Viewed through the lens of a public health socioecological framework, the actors and social and environmental factors, and policy-sensitive participants can be clarified with respect to formulating public health policy in order to identify areas amenable to intervention and health risk mitigation of school-age youth at risk.

Keywords: Adolescent, Concussion, Healthcare access, Finance, Delivery, US

Introduction

In the past decade, few subjects have generated as much public interest as concussive brain injury or concussion. Reports on the long-term effects of concussions and chronic traumatic encephalopathy [1-3], in football have created a new level of awareness about the seriousness of head injuries in the United States (US). National and local organizations representing youth, collegiate and professional sports, as well as health care professionals, have taken significant measures to address this once overlooked issue. This awareness inspired state lawmakers to act, and in May 2009, the state of Washington approved the Zackery Lystedt Law, named after a young football player permanently disabled after he sustained a concussion and prematurely returned to a game. Within

five years of the law's passage, all 50 states and the District of Columbia adopted much of its core principals, backed and promoted by The National Football League (NFL) to address sports-related concussion (SRC). Despite its growing health awareness among educators, coaches, physicians, psychologists, and parents [4], there is still no unified public health policy to screen children entering school with a concussion even though such students are at risk for poorer grades, recurrent concussion, alcohol and drug abuse [5]. Addressing the public health aspects of SRC at the level of schools has been a test of our nation's resolve to ameliorate the health impact of adolescent concussion.

The first section of this paper provides a basic description of the problem of adolescent concussion

including the historical background, clinical definitions, descriptive epidemiology, and magnitude of existing expenditures on adolescent SRC. The second section is a review of published literature about the ongoing effects to address this problem. The third section addresses the problem through the lens of three vehicles from the basic pillars of health care financing and delivery, namely, private payers, The Children's Health Insurance Program (CHIP), and Medicaid. The fourth section compares the current status or state of affairs of adolescent SRC in three states, selected by a top, middle and bottom ten of states with regard to prevalence. The fifth section concludes with a discussion of intended policy changes and strategies to achieve them.

Section 1: The issue of concussion

The Vietnam War in the late 1970s provided the impetus for the management of soldiers with Traumatic Brain Injury (TBI) and the impetus to initiate trauma centers at major medical centers. Moreover, medical centers graded by their level of preparedness to handle major trauma on a 24-hour basis led to the concept of the "golden hour" of emergency care [6]. During this time, trauma management became more sophisticated, and the Glasgow Coma Scale [7] was adopted across the US to classify the severity of TBI. This 15-point Scale included a classification for minor head injuries that fell between 13 and 15. However, at the time, these milder concussions were viewed as insignificant and such patients discharged after an hour of observation were typically not followed-up further. The National Institutes of Health launched a 3-year multicenter pilot study of more than 1,000 moderate and severe TBI patients' data from five major university hospitals into the Trauma Coma Data Bank [8], focusing on immediate neurological impact, and the cognitive and emotional residua caused by TBI. The 1980s led to compelling evidence for diffuse axonal injury (DAI) as the histopathologic basis of mild TBI (mTBI) in experimental animals [9] and affected human subjects who expired due to other causes [10]. The histopathologic basis of mTBI was relevant because brain computed tomography (CT) imaging lacked the sensitivity to identify DAI. This led to acceptance of the neurogenic basis of post-concussive symptoms. During the 1990s, the assessment of concussion was fueled by research that delved directly into mTBI. Tellier and colleagues [11] noted that adolescents and adults with concussive head injury did not constitute a homogeneous pool. Even though brain CT underestimated the number of intracranial abnormalities, it was the test of choice for concussion in the first 24 to 48 hours after injury, especially

in pediatric patients [12] because of its ready availability in Emergency Departments (ED), ease of performance, lower cost, and superior modality in detecting skull fractures. Newly available magnetic resonance imaging (MRI) modalities [13], with their superior ability to detect changes in the brain, was generally employed 48 hours or more after minor head injury [14], owing to its higher cost and limited availability. In a trend that continued into the 2000s, two schools emerged: clinicians who attributed post-concussive symptoms to microscopic brain damage, and others who attributed the apparent psychological factors to malingering. The diagnosis of concussion was problematic since the majority of patients were diagnosed hours, days, or even months after the injury with frequent gaps in memory for recalled loss of consciousness (LOC), the hallmark of mTBI.

The past decade of research has removed any lingering uncertainty that SRC differs from mTBI. DeMatteo and colleagues [15] examined the clinical correlates of the diagnosis of concussion among 434 children with mTBI to identify the factors that led to the use of this term in a regional pediatric center. Proportional hazards results demonstrated that the concussion label was significantly more likely to be applied to children with GCS scores of 13 to 15 ($P = .03$), and was strongly predictive of an earlier hospital discharge. There is comparatively less known about the epidemiology and correlates of SRC in adolescents than in adults. According to the National Electronic Injury Surveillance System-All Injury Program [16], during 2001-2009, the activities associated with the greatest estimated number of mTBI-related ED visits were bicycling, football, playground activities, basketball and soccer among persons older than 19-years, all which could be grouped under the label of SRC. The reported prevalence of a single diagnosed SRC in US high school students age 12 to 18 years in 2016 of 19.5% [17] is similar to regional US surveys [5] and far exceeds the 5% estimate of mTBI visits among adolescents to US EDs by the Centers for Disease Control and Prevention (CDC) [18], suggesting the need for uniformity in reporting of concussion and mTBI in adolescents. The term SRC and mTBI are heretofore interchangeable.

O'Connor and colleagues [19] described the epidemiology of SRC in 27 sports from among 147 high school during the 2011 to 2012 through 2013 to 2014 academic years in the National Athletic Treatment, Injury and Outcomes Network (NATION). The overall SRC rate was 3.89 per 10,000 Athletic Events (AE) (defined as the specific event [i.e., practice, competition] in which the

SRC was reported to have occurred) among 2004 SRC in all sports. Football had the highest overall SRC rate (9.21/10 000 AEs), followed by boys' lacrosse (6.65/10 000 AEs) and girls' soccer (6.11/10 000 AE). No SRCs were reported in boys' crew, cross-country, golf, and swimming and diving and girls' golf. Overall, the SRC rate was higher in competition than in practice (RR 3.30; 95% CI 3.02, 3.60). Player-to-player contact was the most common mechanism of SRC (62.8%) in football (79.6%), boys' soccer (69.9%), boys' lacrosse (60.4%), boys' basketball (59.8%), girls' basketball (53.9%), and boys' wrestling (51.1%). Player-to-player contact accounted for a larger proportion of SRCs in boys than in girls (59.1% versus 39.8%) without significant differences in the distributions of mechanism of injury between competitions and practices. More than 50% of SRCs were caused by equipment contact in boys' baseball (61.1%), girls' softball (60.0%), girls' volleyball (58.1%), girls' lacrosse (57.1%), and girls' field hockey (56.1%). The majority of equipment contact-related SRCs across all sports resulted from contact with the ball (66.8%). In total, 2.9% of SRCs were reported to be recurrent.

Dematteo et al. [15] point out the common misunderstanding among professionals and the lay public that an injury described, as a "concussion" is far less severe than one described as mTBI. While not all blows or jolts to the head result in a concussion, those that do are typically associated with a brief change in mental status or LOC. The immediate and short-term symptoms associated with concussion reflect a primary functional cerebral disturbance rather than structural damage. Secondary physical, neurocognitive and neuropsychological symptoms occur in up to a third of cases and persist for up to several months after primary injury, tapering to about 2.5% at one year [20]. Pervasive symptoms of concussion lead to a disturbance in adaptive independent functioning and the safe performance of activities at home and in school. There have been several widely used classification of mTBI, each with an application to adolescent SRC. A Summary Statement of the Quality Standards Subcommittee of the American Academy of Neurology (AAN) [21] divided concussion into arbitrary grades 1 to 3, based on the severity of concussion as determined by the duration of transient LOC, confusion, or other mental status changes (Tables 1-4). The criteria of the CDC [22] were less specific requiring any period of observed or self-reported confusion, disorientation, or impaired consciousness with memory dysfunction and LOC at the time of the incident. The World Health Organization

(WHO) [23] proposed criteria for mTBI, specifying a GCS score of 13 to 15 at time of presentation to a healthcare professional indicating minor brain injury. In the same year, the Tenth edition of the International Classification of Diseases (ICD 10) [24] enumerated criteria for the diagnosis of post-concussion syndrome (PCS) requiring three of eight symptoms after head trauma: headache, dizziness, fatigue, irritability, difficulty concentrating, memory impairment, insomnia, and intolerance to stress, emotion, or alcohol. The US Department of Veterans Affairs [25] issued clinical guidelines for concussion and mTBI, specifying alteration of consciousness of less than 24 hours and normal structural neuroimaging. New conclusive evidence-based guidelines for the evaluation and management of SRC by the AAN [26], updating the 1993 Practice Parameter [21], differs in the inclusion of factors that mitigate concussion risk, such as diagnostic tools to identify SRC and post-concussive symptoms. Patients with mTBI who have positive findings on neuroimaging, such as subarachnoid hemorrhage and small contusions, are termed "complicated" [27]; however, there is yet a consensus as to whether complicated mTBI constitutes a distinctly different subgroup [28]. Data have been insufficient to show that any intervention enhances recovery or diminishes long-term sequelae following SRC [26]. Winkler and Taylor [29] examined six studies of 421 young people/children concerning treatment of persistent symptoms following SRC or mTBI. Despite a wide variety of medical and nonmedical interventions, all studies reported positive results. However, all were limited in their design, and only one [30] was a controlled trial. Four studies were retrospective case series [31-34], and only one was a prospective cohort study [35]. The natural history of SRCs is significant resolution of symptoms in the first 3 months after injury and further improvement by 12 months [36]. The changes observed in children and adolescents following treatment likely constitute the natural resolution of the symptoms, and therefore cannot be attributed with certainty to the effect of any intervention.

Section 2: How the literature addresses concussion

A useful approach to organizing the literature with respect to adolescent concussion relevant to public health is using a four-level social-ecological model or framework (SEF) which illustrates how levels of society interact with a given health-related problem. This hierarchical model places society and policy at the highest level, notably stakeholders in policy development, dissemination, enforcement, evaluation and revision; with the

Table 1: Features of concussion frequently observed.

Vacant state (befuddled facial expression)
Delayed verbal and motor responses (slow to answer questions or follow instructions)
Confusion and inability to focus attention (easily distracted and unable to follow through with normal activities)
Disorientation (walking in the wrong direction, unaware of time, date and place)
Slurred or incoherent speech (making disjointed or incomprehensible statements)
Gross observable incoordination (stumbling, inability to walk tandem/straight line)
Emotions out of proportion to circumstances (distraught, crying for no apparent reason)
Memory deficits (exhibited by repeatedly asking the same question that has already been answered, or inability to memorize and recall 3/3 words or 3/3 objects in 5 minutes)
Any period of loss of consciousness (unresponsive to arousal)

*Adapted from reference 21.

Table 2: Symptoms of concussion.

Early (minutes to hours):	Late (days to weeks):
Headache	Persistent low-grade headache
Dizziness or vertigo	Light-headedness
Lack of awareness or surroundings	Inattention and impaired concentration
Nausea or vomiting	Memory disturbance
	Easy fatigability
	Irritability and low frustration tolerance
	Intolerance of bright lights
	Difficulty focusing vision
	Intolerance of loud noises and tinnitus
	Anxiety and depressed mood

*Adapted from reference 21.

Table 3: Sideline evaluation.

Mental Status Testing	
Observation	Appearance of associated abnormal symptoms (headaches, dizziness, nausea, unsteadiness, photophobia, blurred or double vision, emotional lability, and mental status changes)
Orientation:	Time, place, person, and situation (circumstances of injury)
Concentration	Reciting 3-5 digits backward
Memory	Recall of 3 word and 3 objects respectively at 0 and 5 minutes
Neurology exam	
Pupils	Symmetry and reaction to light
Coordination	Finger-to-nose, tandem gait
Sensation	Finger-to-nose (eyes closed) and Romberg test

*Adapted from reference 21.

community factors below, followed by interpersonal relationships and intrapersonal factors of those at risk for concussion. In this manner, it is possible to review the published literature for clues to ongoing efforts to address the problem at hand.

Policy level: A series of US state laws have improved
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recognition and side line management of SRC and vary state by state, however, with the same three foundational directives [37]. The first is the education of coaches, parents, and athletes: Schools and sports leagues must inform and educate coaches, athletes, and their parents and guardians about concussion through training and/or a concussion information sheet. The second is

removal from play. Athletes believed to have sustained a concussion or who exhibit signs, symptoms, or behaviors consistent with the injury are removed from practice and game play immediately. Third, Permission to Return-to-Play (RTP). Athletes RTP only after 24 hours with written clearance from appropriate health care providers trained in concussion management. The differences between state laws vary as to the sport programs that must comply, the penalties for those that do not comply, and the designated Licensed Health Care Providers (LHCP) authorized to make RTP decisions. Several states have designated the written clearance to come only from a licensed physician while others have included language specifically allowing physician assistants, nurse practitioners, neuropsychologists, athletic trainers (AT), or physical therapists. Interestingly, state concussion laws do not apply to summer resident or day camps, except those that run licensed sports programs.

Harvey et al. [38] applied a four-stage framework of engagement, enactment, research and reform of states' Lystedt Laws noting that public health lawmaking in this area was consistent with prior standard high-visibility public health law interventions such as mandatory seat-belt laws [39]. The first stage of engagement involves engaging the public and key stakeholders and asking them to rethink the role of government intervention into a previously under-regulated space. With respect to SRC, there were law and policy responses ranging from state statutes to proposed federal RTP legislation [40], a White House summit and congressional hearings, substantial tort litigation [41], and class action litigation against professional leagues. Prior to this engagement stage, prevailing public opinion was that sport participation was a private matter, and government should not take an active role in regulating game content or conduct. Despite the presence of extensive government intervention in school related matters, including student health, sports were traditionally considered outside the public health lawmaking framework. As advocates engaged the public about the connection between education, public health, and youth sports safety, lawmakers were able to make the case for intervention in a more comprehensive manner. As states began to swiftly adopt relatively uniform mTBI legislation, opposition to such bills diminished and support for these public health measures grew, and it became possible to question whether certain aspects of the sport were essential and never subject to change. For example, was playing while injured simply part of the game? The early engagement of a wide-variety of constituencies and their relatively unanimous support for interventions set

the stage for widespread legal policy enactment. From 2009 to 2014, states enacted some form of SRC laws as a response to this long-acknowledged public health problem. Lawmakers recognized that 8.8 million high school athletes, and 1.1 million youth football players, were formally enrolled in school athletic programs, and additional millions of others played recreational sports [42]. Nearly all of the states' initial law-based interventions have focused on secondary prevention efforts to mitigate the downstream effects of concussions [43]. In a short time, public engagement and the influence of interest groups helped to define the problem and shifted public opinion toward approval for such laws. Their enactment, while not without dissent, was a consensus-driven model of public health law intervention. The swift enactment of SRC laws prompted a variety of research inquiries into their actual and potential effectiveness, some of which focused on the direct impact of such laws [44], while others focused on evaluating the engagement of key stakeholders prior to enactment [45] and the experiences of those charged with implementing it at the state level [46]. Engagement with research has historically led to law reform in other areas of public health law such as cigarette smoking in public places, and did so, with respect to youth sports TBI laws. With all states engaged and researchers presenting their initial analyses of the consequences of such interventions, the fourth stage of substantive law reform has been occurring. Consistent with cycles in other public health areas, SRC legislation is entering a reform stage with state legislatures revisiting and revising them.

These changes fall into three main categories:

- (1) Expanding coverage of the law to include younger grades or recreational sports leagues;
- (2) Tightening or clarifying existing requirements; and
- (3) Introducing efforts at primary prevention and from occurring in the first place and improved early detection.

Perhaps most promising is states' recent emphasis on primary prevention, such as mandated limits on contact in practices and scrimmages, as well as safer rules of play. Twenty-two states have made substantive changes to their laws since original enactment, and six states more than once, while others are likely to follow suit [46]. Policy at all levels has been influenced by professional medical organizations and the NFL. Education on these policies and the positions of these organizations is necessary so that all stakeholders involved in a sport setting, including administrators, coaches, parents, and athletes, understand the policies and their role in

ensuring compliance with the policies.

Community level: Communities have linked social ties that form key components in the perceptions of the culture of sports, and community perceptions likewise drive team behaviors. While colleges and teams at the National Collegiate Athletic Association (NCAA) level are required to have an AT and team physician, this is not required at the secondary school level and one is rarely available on site. Athletic trainers are not consistently present at secondary school practices and games to mitigate the health risks of SRC. A cross-sectional study of 8,509 US public secondary schools [47] surveyed from 2011 to 2013 reported that 70% had AT services, including full-time (37%), part-time (31%), and per diem (2%) AT services, while 27% had AT services from a hospital or physical therapy clinic. Athletic training services were available in 48% of schools at all sports practices. Few investigators have directly studied how staffing influences prevention, exposure, and injury outcomes of SRC. There is reason to believe that full-time ATs are generally able to identify and care for more students with injuries. Among 44 ATs who responded in a cross-sectional study using data from the National Athletic Treatment Injury and Outcomes Network about their employment setting, 31% were full-time employees of the high school, and 68% as outreach ATs (i.e., full-time and part-time ATs from nearby clinics, hospitals, and graduate school programs) [48]. Other important contributors in the SEF are the media, local organizations and interactions with health providers. Chrisman and colleagues [49] found that physicians who received a mailed toolkit in the intervention group designed to increase knowledge about concussion were overall less likely to recommend next day return to play after a concussion (adjusted OR = 0.31, 95% CI = 0.12-0.76) than controls.

Interpersonal and intrapersonal levels: Teammates can play an important role in the early identification of SRC as perceived norms, shaped by observations of, and interactions with members of the referent population, are an important determinant of whether an athlete reports a suspected concussion.

Kroshus et al. [50] noted that SRC-reporting norms were generally misperceived with athletes tending to think that they themselves had safer attitudes about SRC reporting than their teammates. Perceived norms were associated with symptom reporting intention, independent of the team’s objective reporting norm. A social norms approach to SRC education, in which misperceived group norms are corrected and shifted in the direction of safety, is an important avenue for program development and evaluation research aimed at the secondary prevention of harm from SRC. A strategy that engages coaches and teammates in setting safe injunctive team norms, and that gives a voice to all team members, can disrupt the spiral of silence that perpetuate misperceived norms and could help in shifting true norms in the direction of SRC safety. Athletes who experience pressure from multiple sources, not just from coaches and teammates but also from parents and fans, have a lower concussion reporting intention than athletes who only experience pressure only from coaches and teammates. Appropriate SRC education for athletes developed in conjunction with interventions at the other levels of the SEF sets the stage for the transfer and sustainability of the information and skills that integrate at the athlete’s level.

Section 3: Addressing concussion through major finance vehicles

Private payer insurance, CHIP and Medicaid are three important vehicles for the healthcare financing of adolescent concussion care. The US healthcare system relies heavily on private health insurance, which is the primary source of coverage for most Americans. Individual private payer insurance, whether underwritten by an employer or obtained separately in the marketplace, operates as a contract between an insurance company and the individual, or its sponsor, to cover the cost or a portion thereof, through premiums, deductibles, co-payments, and co-insurance, with certain exclusions, coverage limits, and out-of-pocket maximums, and subject to plan provisions for in-network or out-of-network providers, prior authorizations, and applicable prescription drug plan benefits. Care that is provided to

Table 4: Grading scale for concussion.

Grade 1:	Transient confusion, no loss of consciousness, concussive symptoms or mental status abnormalities on examination resolve < 15 minutes.
Grade 2:	Transient confusion, no loss of consciousness, concussion symptoms or mental status abnormalities on examination last > 15 minutes.
Grade 3:	Any loss of consciousness, either seconds or minutes.

*Adapted from reference 21.

beneficiaries and their children can be tracked through claims made, itemized in the explanation of benefits, that for services provided and covered or excluded. Like the government insurances, Blue Cross Blue Shield uses TBI waivers [51]. Whether the patient is a new member or has an existing membership, individuals of all ages may apply for a waiver to be able to access more specialized services and programs relating to TBI, including adaptive equipment, day-to-day assistance, and other medical and physical needs [52]. Blue Cross Blue Shield also offers specialized support for members with complex or chronic health conditions including brain injury [53]. This service pairs members with a care manager, a registered nurse, specialized health coach or behavioral health clinician who provides support and aid with care coordination at no additional cost.

The analysis of claims for services rendered for concussion victims by Blue Cross Blue Shield has facilitated insight into the care rendered to adolescents with concussion. A six-year study [54] by Blue Cross Blue Shield Health of America BCBSA Report series, a collaboration between BCBSA and Blue Health Intelligence, used a claims database to uncover key trends and insights into health care affordability and access to care examined in the medical claims of 936,630 diagnosed concussions for BCBS commercially-insured non-Medicare members from 2010 through 2015. Methodologically, it considered seasons comprised of three month groups, with fall from September through November, winter from December through February, spring from March through May and summer from June through August. Concussion rates were presented as average yearly rates per 1,000 members. The noted a 71% increase in concussion rates from 8.9 to 15.2 diagnoses per 1,000 members in children aged 10 through 19 years, compared to a 26% increase, from 1.9 to 2.4 diagnoses per 1,000 in adults aged 20 to 64 years. The increases occurred from 2010 to 2013 when most states enacted concussion legislation mandating reporting. Children age 10 to 19 years were five-times more likely to be diagnosed to be with a concussion than all other age groups combined, with the most dramatic spike in its incidence occurring in the fall, when the most popular school-based and extramural contact sports such as football, soccer and lacrosse are in season. Boys had an overall concussion rate of 7.0 per 1,000 that increased 48% from 11.5 to 17.0 per 1,000, compared to girls who had an overall concussion rate of 3.7 per 1,000, increasing 118% from 6.1 to 13.3 per 1,000 members during the study period. The national average of the rate of concussion diagnoses increased nearly

two-fold in all states between 2010 and 2015, especially in those age 10 to 19, from 8.9 per 1,000 members to 15.2 per 1,000 members, with the highest rates (nearly three-fold) in the Northeast. The percentage of concussion patients across all ages diagnosed with post-concussion syndrome nearly doubled over the study period from 7.3 percent to 13.2 percent. Adults age 20 through 64 who were diagnosed with a concussion in 2015 were subsequently diagnosed with post-concussion syndrome 15.7 percent of the time, which was a higher rate than members ages 10 through 19 at 12.4 percent. Females ages 20 through 64 accounted for 61.3 percent of all post-concussion syndrome diagnoses compared to 38.7 percent for males. For patients ages 10 through 19, post-concussion syndrome was diagnosed equally between males and females.

Medicaid is a federal and state funded insurance that provides health coverage to eligible low-income American adults, children, pregnant women, elderly adults, and people with disabilities administered by states according to federal requirements [55]. When an individual goes to a doctor or hospital with a concussion, any inpatient treatment or potential hospital stays would be covered through Medicaid's standard care. If the individual does not have insurance, the hospital's case manager would file a standard Medicaid coverage application, in the case of New York, the Access NY Health Care application. In doing so, the individual will have a mandatory enrollment in Medicaid Manage Care. Having Medicaid Manage Care provides individuals to access network providers for other insurances such as Blue Cross, depending on the State and County they are in. They will also have access to certain state network providers for certain programs such as transportation, outpatient substance use, mental, assisted living, school based and Indian tribal provider services only [56]. If a doctor or other health care professional that the brain injury sustained by the individual as severe and that the individual requires long term care or other specialized services, there are a couple steps to be taken through the waiver program system which may help with gaining connections to more immediate access and more qualified and compressive serves that provide not just medical care but also living assistance. Either the child's surrogate or case manager can file a Home & Community-Based Services (HCBS) request. New York State applicants fill out Access Supplemental form A and in doing so, can receive coverage for long term care raging from home attendants with day to day assistance, skilled nursing in the home, assisted living leading into permanent

assistance [57]. Clients whose medical needs do not fit with standard Medicaid and Medicaid Care Manager plans may also apply for a Traumatic Brain Injury Waiver, a more specific type of HCBS waiver [58]. The Social Security Act lists certain services that may be provided by the HCBS waiver and the waiver is also required to be cost neutral [59]. This waiver allows the individual to get access to more specialized care targeting brain injuries such as, assistive technology (special medical equipment and supplies), home and community support services, and other Transitional services [60]. Individuals with this waiver may also obtain an exemption from the Medicaid manage care. This is important because Medicaid manage care only provides access to other health insurances standard care, however, an individual with brain injuries may require more specialized care. By being exempt from the Medicaid manage care, the individual has access to all the state network providers, including special service providers, which are not accessed through the standard Medicaid coverage. Additionally, Medicaid only covers twenty physical therapy sessions; however, the waiver provides an exemption to this policy allowing individuals to have more care.

CHIP, similar to Medicaid, provides health coverage to eligible children, through both Medicaid and separate CHIP programs [61]. Due to Congressional changes, CHIP lost its federal funding in September of 2017 [62]. Several states continued to fund programs similar to CHIP in order to provide care for children using their remaining funding from previous years. In January of 2018, Congress approved a 6-year extension, however, States like New York, have continued to have their own program like Child Health Plus for the time being. A child who does not qualify for Medicaid can be enrolled in Child Health Plus and select a health plan based on the insurers in the county [56]. Depending on the family's income and other financial information, the child may qualify for free insurance or insurance that requires payment of premiums. CHIP or Child Health Plus is a secondary form of insurance that covers the costs of providers from the health plan yet it also has its own network of providers. A child who is considered disabled may apply for Medicare, a government insurance that covers disabled individuals. With this insurance, 80% of the cost is covered and long-term care services are included due to the individuals certified disability. If the child qualifies for Medicaid as well as Medicare, Medicare covers 80% and Medicaid covers 20% of the service fees. Children who are in Medicaid only, may apply to the waivers for TBI or longer term care waivers depending on state age eligibilities.

Unlike the Blue Cross Blue Shield study [34], there is no accessible claims database revealing key trends and insights into health care affordability and access to care.

Section 4: How is concussion addressed in three different states?

Three states, New York, Idaho, and Massachusetts were randomly chosen for comparison in the way that concussion is respectively addressed based upon several indices:

- 1) Federal TBI grants received by each of the states and their respective matching funds under the TBI Act of 1996 (P.L. 104-166) between 2014 and 2018;

- 2) The number of Medicaid 1915 (c) home and community-based services (HCBS) waivers and

- 3) The scope and compliance of enacted Lystedt Law in each of the states.

Federal TBI grants: The TBI Act of 1996 (P.L. 104-166) signaled the initial national recognition of the need to improve state TBI service systems. It authorized funding to the US Department of Health and Human Services (DHHS) for prevention, education, research and grants to States to increase access to services for individuals with TBI and their families. Reauthorizing legislation was passed as part of the Children's Health Act of 2000 (P.L. 106-310) that included grants for state Protection and Advocacy Systems to expand their services to include TBI. In 2008, legislation reauthorized the programs. Since 1997, Federal funds have been awarded to 48 States, District of Columbia, and two Territories through a competitive grant process for purposes of developing, expanding and improving access to service delivery for individuals with TBI and their families. It required states to match Federal dollars in the amount not less than \$1 for each \$2 Federal funds provided under the grant. It also required the DHHS to coordinate activities under this section with other Public Health service agencies. According to the Federal TBI program State Grant Fact sheets between 2014 and 2018, NYS received \$2,630,324 in Federal implementation partnership grants and provided approximately \$1,508,499 in matching funds [63], followed by Idaho which received \$2,317,814 in Federal TBI funds and provided \$1,178,141 in matching support [64], and Massachusetts, with \$1 million in Federal partnerships grants to which it matched \$500,000 in support [65], and each over the four year period.

HCBS waivers: In 2007, the Center for State Health Policy [66] surveyed states that operated Medicaid waivers targeted to individuals, including young adults

and children with TBI that included the cost and number of individuals served for years 2002 to 2006. Every state (except Arizona with its own long-term care system as an 1115 Waiver) had HCBS waivers granted under section 1915 (C) of the Social Security Act. Although initially small, such waivers have grown significant in recent years doubling from 5,400 individuals served in 2002 to 11,214 in 2006, at a cost of \$115 million in 2002 to \$327 million in 2006. Providing HCBS to individuals with TBI proved to be less expensive than providing institutional services. Such waivers are cost-neutral, meaning that in any fiscal year for medical assistance provided with respect to such individuals, they do not exceed 100% of the average per capita expenditure that the state estimated would have been made in that fiscal year for expenditures under the state plan for such individuals had the waiver not been granted (Social Security Act, Section 1915(c)(2)(D)). Among the states surveyed in 2006, NYS Waivers, first established in 1995, led the states with 1,953 individuals served, with Idaho's Waiver program established in 2001, serving the least, 19 individuals in 2006; and Massachusetts Waiver plan established in 2001, serving 90 individuals. The principal driver of such Waivers has been effort on the states' part to repatriate citizens from high cost out-of-state facilities and return to the community. While it is not possible to glean the number of children served by Waiver for concussion, these data give a clue to the resources and commitment the individual states have to effectively managing states resources from the federal government earmarked for TBI.

Key components of states' Lystedt laws: The purpose of Lystedt laws was to take steps to strengthen the rules on TBI management and notably applied to student athletes. However States differ in its breadth and which is evident in the three states chosen for comparison. For example, all three state concurring on the necessity that student athletes suspected of a concussion be removed from play, and that before returning to play that they be cleared by a health professional trained in management of concussion or by a licensed physician; and all concur that that competing athletes and their parents be educated in concussion recognition. However, only New York and Massachusetts laws require formal training for coaches in concussion recognition, and Massachusetts alone requires parents be notified of suspected or diagnosed cases of concussion in their children.

Compliance with states' Lystedt laws: The experience of NYS and Idaho's respective Lystedt legislation are compared emphasizing challenges to

effective implementation and compliance.

New York State's Lystedt Law, (Bill No. S03953) enacted as The Concussion Management and Awareness Act that went into effect in 2011 was assessed in a survey study by Kajankova and colleagues [67]. The authors evaluated its implementation and compliance at the school district level in a sample of 52 districts (47 Westchester County districts and 5 "big city" districts across NYS [Albany, NYC, Buffalo, Syracuse, and Rochester]) that were queried as to their management of procedure and practice documents mandated for compliance with the State's 2012 Concussion Awareness and Management Act ("the Act"). There was a significantly higher wealth ratio in Westchester County compared to big inner city districts (1.63 vs. 0.44), with fewer students (3759 vs. 222,612) and increased annual expenditure per pupil (\$26,229 vs. \$20,236). Westchester County districts varied in their compliance noting rates ranging from 30% to 100% (mean, 76%) in comparison to the less variable and higher overall compliance with the required items among the big city districts, with rates ranging from 81% to 96% (mean, 88%). Westchester County and big city districts were similar in two areas of lowest compliance including the provision of information relating to concussion in the any interscholastic sports permission form to a parent or guardian (36% versus 20%); and authorization for a licensed physician to resume athletic activity kept on file in the student's permanent health record (50% vs 60%). Although the tracking of concussions effectively in schools will require a reporting process, NYS' law does not require medical professionals, tasked with evaluating children after a concussion, to train in brain injury, which can have negative short- and long-term consequences. The Act also does not adequately address the tracking of concussed students and their ongoing symptoms and long-term outcomes. The fact that no district in the study by Kajankova and colleagues [67] achieved a 100% compliance rate indicates obvious gaps in implementation of the Act within NYS school districts.

The implementation of Idaho's Lystedt Law (HB-548) [68], enacted as Youth Athletes and Concussion Guidelines and Requirements that went into effect in 2012, initially contained all three elements of the law including the need for education, removal of the student athlete from play, and medical clearance before returning to play. According to Amberg [69], Idaho school districts' worried about the liability of school coaches and medical personnel that care might not be rendered correctly and children would return to play before being ready, convinced legislators to strike out the last two elements of the bill. Simply stated,

requiring a signed acknowledgement form might limit a school's liability, but falls short of providing parents with an adequate amount of information about concussive injury or the school's need to withhold an athlete from sports participation following the display of concussion symptoms under pressure from local constituents, the National Federation of State High School Associations, and the last update in May 2012 of the guidelines of the CDC's Heads Up Program [70], HB-548 was replaced by HB-632 [71], containing all three elements. The compliance of Idaho's concussion law was surveyed by Faure and coworkers [72], after passage of HB-632, querying three primary areas of athletic directors' self-reported views of school compliance, the process that schools used in order to administer the required concussion education, and the methods schools used for appropriate concussion management. Specific questions in the survey targeted the presence, history, and components of each school's concussion management policy/protocols; the process of concussion education directed towards coaches, parents, and athletes; and the process of managing concussion incidence within each school. Idaho's schools faced serious obstacles reflecting their earlier resistance in complying with mandated concussion laws in assuring provider access, parent cooperation, and heightened awareness with only 32% of high schools providing full-time, daily access to a licensed athletic trainer to attend to injuries sustained during sport practices and games.

Section 5: Intended changes and strategies to achieve them

Children who sustain SRC at different ages face different challenges. Young children face increased vulnerability due to concomitant maturational periods of brain and neuropsychological development; whereas older adolescents in higher grades face greater demands on cognitive, organization, and problem-solving skills due to deficits in executive functioning. Educational issues that emerge later related to concussion may be inappropriately managed or incorrectly attributed to other factors. The solution begins with identifying concussion at the time of injury and receiving a proper assessment by trained personnel. Obtaining prompt medical care by a licensed health care provider, knowledgeable in SRC and mTBI, who can relate the findings to school officials, ensure consistency in healthcare and educational services. A combination of diagnostic tests as compared with individual tests is likely to improve diagnostic accuracy of concussion [26]. Neuroimaging employing brain CT or MRI are not used to diagnose SRC, but may be obtained to rule out serious head injury including and pervasive

Annal Behav Neurosci, 1(1): 94-107 (2018)

PCS. Such children with pervasive neurocognitive and neuropsychological deficits benefit from specialty evaluations to determine appropriate outpatient services and school follow-up assessments.

Viewing SRC through the lens of a public health SEF (Table 5) (Figure 1) clarifies the actors and social and environmental factors relevant to SRC, and identifies areas amenable to intervention and health risk mitigation of SRC in school-age at-risk youth [73]. At the societal and policy level, state laws mandating education, removal from play to minimize further injury, and elucidating the roles of school personnel in reporting and managing suspected SRC, are all important steps forward. Legislative and educational policies represent the minimum acceptable standard. Existing models of older age populations including NCAA and professional sports leagues provide a potentially valuable precedent for policy at the younger age levels. Individual school district, schools, and team personnel may demonstrate differing levels of compliance to the legal statutes, often independent of financial means yet held to the same standards, offer the opportunity for normative responses to SRC and its managements integrating community-wide stakeholders. Individuals supervising high school athletes should manage them more conservatively regarding return to play than older student athletes. At the interpersonal and intrapersonal levels, the healthy social ties that form between athletic school personnel, teammates and parents will drive the interest in understanding SRC, including its reporting and prevention by avoiding secondary injuries and reinforcing healthy behaviors.

Figure 1: The Socio-Ecological Framework can be used to identify areas of policy reform in adolescent sports-related concussion.

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Table 5: Planned approach to achieve improved health outcomes in SRC.

Levels	Goal	Strategies
A. Societal and Policy Level	Understand State Laws and Educate Stakeholders	i) Work with athletic personnel and school administrators, and risk-management personnel to develop best practice concussion policies based upon state laws to ensure compliance at the school level. ii) Develop good relationships and sound concussion policy, integrating health care providers to ensure health policy management protocols and bidirectional communication with school officials and parents. iii) Support and conduct research on policy effectiveness and compliance.
B. Community Level	Ensure Timely Identification and Disposition of SRC	iv) Work with athletic personnel and medical-providers to determine event coverage, practice emergency action plans, proper fitting of equipment, safety of sports facilities and playing surfaces. v) Implement and practice organization's concussion safety and policy measures. vi) Promote positive messaging and communication of SRC among athletic personnel, school officials, team players, parents, community health providers, local employers and insurance stakeholders.
C. Interpersonal Level	Educate Parents and Teammates in Concussion Recognition and Response	vii) Preseason team and school meetings to educate players and parents and review appropriate policies and post-injury scenarios. viii) Promote anticipatory guidance to concussion patients and families throughout the recovery course.
D. Intrapersonal Level	Educate Student Athletes	ix) Provide opportunities for experiential and observational learning ensuring efficacy in changing least knowledge and positively impacting attitudes, norms, reporting intention and misperceptions. x) Educate student athletes about appropriate sports skills aimed at keeping head out of play and following game rules.

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